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Evaluation of Modified Air Traffic Control Phraseology for Area Navigation (RNAV) Standard Instrument Departure (SID) Clearances

Phase III: Operational Validation with Pilot Training Video

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Technical Report

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16. Abstract Area Navigation (RNAV) procedures are being designed and implemented for terminal departures and arrivals. Potential benefits of introducing these procedures include: 1) more fuel efficient and time saving routings 2) reduced dependence on radar vectoring, altitude and speed assignments that contribute to frequency congestion 3) more efficient use of inherently limited terminal airspace. As operational implementation of RNAV procedures began, analysis of occasional failures to comply with RNAV Standard Instrument Departure (SID) clearances focused attention on a number of issues. This study focused on issues involving Air Traffic Control (ATC) phraseology used for issuing clearances to join a departure route and for returning aircraft to SIDs, after issuing an altitude, speed, and/or heading change. In these cases, ATC may not have effectively communicated the intent of the issued instruction. The Pilot/Controller Phraseology and Procedures Action Team (P/CPP AT), under the Departure and Landing Workgroup of the Performance Based Operational Aviation Rulemaking Committee (PARC), addresses such pilot/controller procedure and phraseology issues. The P/CPP AT sponsored this study. They identified an operational need to establish Climb Via procedures and phraseology for SIDs, similar to the "descend via" procedures and phraseology currently in use for Standard Terminal Arrival (STAR's). Accordingly, the P/CPP AT drafted new procedures and phraseology for addition to FAA Order 7110.65, describing the Climb Via instructions. The proposed phraseology was developed to address potential misunderstandings of RNAV SIDs. As a result of this study, the proposed "Climb Via" phraseology was refined, and a Climb Via Pilot Informational video, was developed to clarify phraseology and procedures.					
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Executive Summary

During the past two years the Federal Aviation Administration (FAA) has begun the deployment of new Area Navigation (RNAV) Standard Terminal Arrivals (STARs) and Standard Instrument Departures (SIDs) at selected airports across the National Airspace System (NAS). Working in conjunction with NAS users, the FAA has closely monitored operational performance and accrued benefits. Although RNAV procedures have shown promise, some deviations from controller clearances have caused either the shut down of, or modification to, RNAV procedures. Many cases of non-compliance with an RNAV SID clearance have been traced to human factors issues associated with pilot/controller or pilot/Flight Management System (FMS) interaction. These issues included misunderstandings concerning the actual clearance sent, and misunderstandings of the intent of the clearance. Because of these anomalies, the FAA and industry have taken actions to determine the nature of the human issues associated with the problem, and to develop more effective guidance and instructions to pilots and controllers for the use of RNAV SIDs. In analyzing the failures to comply with RNAV SID clearances, one problem that surfaced was the Air Traffic Control (ATC) phraseology for issuing the clearance to rejoin the departure route and return the aircraft to the SID. This clearance did not effectively communicate the intent of the issued instruction to all pilots.

The Pilot/Controller Phraseology and Procedures Action Team (P/CPP AT) is an action team under the Departure and Landing Workgroup of the Performance Based Operational Aviation Rulemaking Committee that was established to address such pilot/controller procedure and phraseology issues. The P/CPP AT is composed of air traffic, aviation, pilot, and controller union subject matter experts, and has proposed changes to the FAA Order 7110.65, the Aeronautical Information Manual (AIM), and the Aeronautical Information Publication (AIP). The P/CPP AT has identified an operational need to establish Climb Via procedures and phraseology for SIDs similar to the “descend via” procedures and phraseology in current use for STARs. Accordingly, the P/CPP AT drafted new procedures and phraseology for addition to FAA Order 7110.65 (Air Traffic Control), paragraph 4-5-7, describing the Climb Via instructions [see Appendix C Draft Document Change Proposal (DCP)]. The proposed phraseology was developed primarily to address potential misunderstandings of RNAV SIDs, however, the issues addressed by the new phraseology also will apply to all SIDs.

The primary focus of this effort was the operational validation of draft Climb Via procedures and phraseology. Within the context of an RNAV SID, we also investigated issues surrounding the effective depiction of a “SID Top Altitude” (the highest altitude an aircraft is cleared to on a given departure). The goal was to exercise the new ATC instructions in an operational environment and assess the clarity of the Climb Via instruction through pilot performance and subjective feedback. The participant pool consisted of Boeing 747 and 737 pilots who had a wide range of RNAV SID experience.

Overall, the Climb Via concept was viewed favorably by the majority of the participants. They were encouraged by the FAA’s actions, soliciting input from the users prior to

implementation. Most pilots agreed that with some minimal training, Climb Via would be beneficial to NAS operations.

1. Introduction

1.1 Purpose

This document presents the plan and results for the third phase of the validation effort. The first two phases were completed by the Simulation and Analysis Group of the Federal Aviation Administration (FAA) William J. Hughes Technical Center (WJHTC). The focus of the first two phases was to evaluate modified phraseology and procedures for use by terminal air traffic controllers when issuing Conventional and Area Navigation (RNAV) Standard Instrument Departure clearances (SIDs). The first phase was completed in November 2004. The second phase was completed in May 2005, and final report issued in September 2005. The Pilot/Controller Phraseology and Procedures Action Team (P/CPP AT) recommended that a third phase of validation be conducted.

The primary focus of this third phase was to evaluate the effectiveness of a pilot training video on reducing the pilot uncertainty regarding new Climb Via procedures and phraseology observed during the first two phases of validation.

Note: Climb Via ATC procedures and phraseology and flight simulation scenarios have, in some cases, been modified from those in place during the Phase II study. For this reason, some data recorded during this phase will not be wholly comparable to data recorded during the previous phase. It is expected that the results of this study will contribute to discussions supporting Climb Via operational plans. For the reasons just mentioned, this study alone should not be the sole basis for any decisions.

1.2 Project Background

Area Navigation (RNAV) is a navigation method that permits aircraft to operate on any desired flight path within the coverage of station-referenced navigation aids [e.g., Distance Measuring Equipment (DME)], within the limits of equipment onboard the aircraft [e.g., Global Positioning System (GPS)], or a combination of both. The FAA has committed to the evolution of the National Airspace System (NAS) from conventional navigation over routes defined by ground emitted navigation aid signals to a system that will rely exclusively on the use of RNAV. As a part of this restructuring of NAS airspace, the FAA is implementing a performance-based navigation concept in which aircraft will be required to comply with specified performance and functional requirements to conduct RNAV procedures. Under the concept of Required Navigation Performance (RNP), individual aircraft will be qualified to fly routes and procedures defined by specific functional RNP levels.

Originally used as a tool for flying conventional ground-based routes, RNAV is being used to permit direct flight between any two points in en route airspace that can be defined solely as geographical coordinates. In addition, RNAV procedures are being designed and implemented for terminal departures and arrivals. The potential benefits of introducing these new procedures

for appropriately equipped aircraft include: 1) more fuel efficient and time saving routings, 2) reduced dependence on radar vectoring, altitude and speed assignments that contribute to frequency congestion, and 3) more efficient use of inherently limited terminal airspace.

1.3 Problem and Proposed Solution

In recent years the FAA began the deployment of new RNAV Standard Terminal Arrivals (STARs) and SIDs at selected airports across the U.S. Working in conjunction with cooperating air carriers, the FAA has closely monitored operational performance and accrued benefits. Although recordings of the accuracy and consistency of flight paths using the new RNAV procedures showed excellent performance in many cases, several exceptions were noted in the case of aircraft departing on RNAV SIDs. Some of the deviations from the required three-dimensional departure track were attributed to navigational equipment failures and errors. Other cases of non-compliance with an RNAV SID clearance were traced to human factors issues associated with pilot/controller or pilot/Flight Management System (FMS) interaction. These issues included misunderstandings concerning the actual clearance sent, and misunderstandings of the intent of the clearance. Because of these anomalies, the FAA and industry have taken actions to determine the nature of the human issues associated with the problem, and to develop more effective guidance and instructions to pilots and controllers for the use of RNAV SIDs.

Further analysis of the failures to comply with RNAV SID clearances focused attention on issues involving Air Traffic Control (ATC) phraseology used for issuing clearances to join a departure route and for returning aircraft to SIDs after issuing a required altitude, speed, and/or heading change. In these cases, ATC may not have effectively communicated the intent of the issued instruction. This study is one of the primary focus areas.

The Pilot/Controller Phraseology and Procedures Action Team (P/CPP AT), under the Departure and Landing Workgroup of the Performance Based Operational Aviation Rulemaking Committee, was established to address such pilot/controller procedure and phraseology issues. The P/CPP AT, composed of air traffic, aviation, pilot, and controller union subject matter experts, proposed changes to the FAA Order 7110.65, the Aeronautical Information Manual (AIM), and the Aeronautical Information Publication (AIP). They identified an operational need to establish Climb Via procedures and phraseology for SIDs similar to the “descend via” procedures and phraseology in current use for STARs. Accordingly, the P/CPP AT drafted new procedures and phraseology for addition to FAA Order 7110.65 (Air Traffic Control), paragraph 4-5-7, describing the Climb Via instructions [see Appendix C: Draft Document Change Proposal (DCP)]. The proposed phraseology was developed primarily to address potential misunderstandings of RNAV SIDs, however, the issues addressed by the new phraseology will apply to all SIDs.

2. Objectives

Previous efforts were conducted in two phases. Phase I, completed in the fall of 2004, was a series of cognitive walkthroughs conducted with commercial and general aviation pilots. The walkthroughs were designed to elicit narrative descriptions of the actions pilots would take in the

context of selected departure scenarios in order to characterize the nature of any potential problem(s) that may exist in interpreting and executing RNAV SID clearances using the proposed Climb Via phraseology.

Phase II of this effort focused exclusively on the issues that were identified as potential problems during the cognitive walkthroughs. These issues ranged from pilot misunderstandings of clearances to the potential inability of the onboard flight management system (FMS) to properly execute those clearances. This effort was conducted in flight training simulators and involved assessment of pilot responses to several different scenarios that were specifically designed to address the issues raised in Phase I. In addition, pilot/co-pilot communication, and the associated interaction with their navigational equipment as a function of scenario type were examined.

Significant pilot uncertainty was observed during Phase II simulations. The P/PPP AT analyzed the different areas of pilot uncertainty and recommended a Phase III evaluation. Phase III, documented in this report, evaluated the effects of limited aircrew training, presented in the form of a short pilot training video, on pilot uncertainty.

3. Method

3.1 Participants

Phase III participants consisted of 26 B-737 qualified pilots (e.g., 13 flight crew pairs). Eighteen participants were commercial airline pilots and 8 were Navy and FAA pilots.

3.2 Simulation Environment

The simulations were conducted in a certified Boeing 737-800, full motion cockpit simulator, located at the FAA Mike Monroney Aeronautical Center, in Oklahoma City. The B737 was a fully detailed replica of a B737 flight deck, in which all instruments, controls, and switches operated in the same manner as in the actual aircraft. The B737 featured a digital control loading system, a six-degree-of-freedom synergistic motion system, and a fully integrated flight management system that provided aircraft guidance and control. The simulator offered digital video/audio recording capabilities, which allowed the research team to conduct post simulation content analyses on crew resource management (CRM). Digital sound systems provided aural cues in the cockpit, while a programmable visual display system provided a 180-degree horizontal/ 40-degree vertical field of view.

3.3 Procedure

Prior to the start of the exercise and data collection, each pilot read and signed an informed consent form explaining that their participation in this study was strictly voluntary and that their privacy would be protected (see Appendix D). The pilots were then interviewed to obtain information regarding the primary aircraft type and equipage, the pilot's flight background, and his or her experience flying RNAV terminal procedures. Following the background interview, the crews watched a training video presenting information regarding RNAV SIDs, and Climb

Via phraseology. Following the video, and without any discussion with each other or with the research team, the pilots took a written test (see Appendix E) on subjects covered in the training video. Crews then entered the simulator for pre-flight and flight activity.

Participants were allowed to fly a practice departure. These practice runs offered participants the opportunity to get acquainted with the simulation environment and each others' operating procedures (in the case where the flight crews were composed of participants from two different airlines/agencies). Following practice departures, they were given the SHEAD FOUR (RNAV) Departure SID (Jeppesen) chart and instructions to prepare themselves and aircraft systems for flight. These standard aeronautical departure plates included a graphical representation (not to scale) of the SID showing all route legs, compass directions, leg mileages, waypoints, and restrictions for performing the procedure. The departure procedure also included textual information describing the SID route from each departure runway, take-off minimums, ATC contact frequencies, and relevant notes.

3.4 Climb Via Pilot Training Video

The objectives of this training product were grouped into five basic knowledge areas, and are described in this section. Note that some of the information contained in the product is associated with RNAV SIDs, in general. The previous study indicated that providing some training regarding the unique characteristics of RNAV SIDs, as well as some nuances of their integration in flight deck systems, could improve pilot understanding and reduce the potential for pilot uncertainty and other problems that could potentially contribute to aircraft deviations.

Training Objective 1 – RNAV SID

This objective described general characteristics of today's RNAV SIDs.

Training Objective 2 – CLIMB VIA

This objective provided background on how Climb Via phraseology was developed, and its operational intent. The basic premise of this new phraseology was that Climb Via means the pilot is cleared to navigate laterally, and vertically at the pilot's discretion, so as to comply with all speed and altitude restrictions published on a SID.

Training Objective 3 – TOP ALTITUDE

This objective described SID and SID Transition Top Altitudes. This training emphasized the operational meaning of a SID Top Altitude, and where this information could be found. The SID (or SID Transition) Top Altitude was the altitude limit to which the pilot was expected to climb to, after meeting all previous published SID restrictions. This altitude limit was annotated on the SID, and was not required to be verbally, or otherwise issued by ATC if the pilot was cleared via the SID.

Training Objective 4 – FLIGHT DECK SYSTEMS/SID REVIEW

This objective emphasized the importance of careful review of the SID, and proper flight deck systems programming of runway, departure procedure, routing, restrictions, etc. Flight deck systems programming, particularly that of runway selection, was an issue that surfaced in live operations during the time period when Phase II testing was underway.

Training Objective 5 – FLIGHT SCENARIOS

This objective demonstrated Climb Via phraseology and procedures. It presented various operational flight scenarios demonstrating proper interpretation and execution of RNAV SIDs and ATC Climb Via instructions.

3.5 Airspace and Scenarios

All of the RNAV scenarios were conducted using the Las Vegas/McCarran International Airport (LAS) airspace and the SHEAD FOUR DEPARTURE (RNAV) SID (see Figure 1). The SHEAD FOUR was selected because it contained restrictions to cross waypoints at or below, at, and at or above specified altitudes. It also included waypoints without associated restrictions. The environment provided by this SID permitted an examination of several test scenarios where misunderstandings of clearances or the ability of the FMS to execute clearances could cause deviations or lead to ambiguity in the cockpit.

The four test scenarios developed for Phase II were used during this Phase III study, although scenario numbers two and four were slightly modified. The test scenarios (see Table 1 Scenario Descriptions) consisted of joining the SID enroute, as well as clearances to depart and rejoin the SID where confusion had existed regarding appropriate altitudes. More detailed descriptions and the associated ATC phraseology for each scenario can be found in Appendix F. The clearances issued varied with the type of scenario (rejoining the SID, speed restrictions, altitude change, etc.).

In these scenarios, verbal and/or printed departure clearances were provided to the pilots prior to takeoff. Participants from airlines that use pre-departure clearances (PDC's) were provided a representative hard-copy PDC, in lieu of verbal departure clearances. The Jeppesen SID plates depicted the SID Top Altitude limit (FL 190) in an Altitude block adjacent to the Routing information.

In the Phase I cognitive walkthroughs, an additional altitude note “block” was provided on the SID plate, and was found to sometimes reduce confusion concerning the full clearance to climb to the initial altitude limit. Concurrent with that study, however, industry working groups were discussing options for providing this information somewhere on the SID plate, as well. For Phase III, the ultimate Jeppesen modification to the published SID plate rendered our additional SID Top Altitude limit depiction unnecessary.

All flight crews experienced all four scenarios. The presentation order was counterbalanced to eliminate sequence effects. Each scenario began prior to takeoff with a departure clearance and with the aircraft situated at the appropriate end of the assigned runway. In addition, simulator motion was enabled for all runs and there were no prescribed anomalies (system malfunctions, clear air turbulence, etc.).

Table 1. Scenario Descriptions

Scenario	Event	SID	Runway
ONE	Speed change and downstream SID restriction change	SHEAD 4	25R
TWO	SID altitude restriction change, followed by a short cut	SHEAD 4	25R
THREE	Vector off SID followed by short cut back onto SID	SHEAD 4	25R
FOUR	SID short cut, followed by vector (to join SID)	SHEAD 4	7L

3.6 Data Collection

Two members of the P/PPP AT research team were present in the cockpit behind the flight crew. One member performed the role of ATC, issuing clearances and interacting with the flight crew as he would if controlling live traffic, while the other member recorded events and whether or not the pilot and/or equipment complied with the scenario-specific clearances. Following the completion of the test runs, crews were debriefed in the cockpit, as well as in a debrief room.

The debriefing consisted of the research team soliciting feedback and clarifying comments from the participants concerning their particular behavior and experiences during their four departure flights. The research team also collected pilot opinions regarding their perception of the effectiveness of the training video.

Audio and video from all flight simulation runs were taped for further post-simulation analysis.

4. Results

A major benefit of RNAV SIDs was the reduction in number, length, and complexity of voice communications, as well as minimizing ambiguity. For the purposes of this study, we operationally defined ambiguity as pilot to pilot uncertainty and/or pilot to ATC uncertainty. As with Phase II, pilot performance data regarding each ATC Climb Via instruction, and RNAV SID compliance in general, was categorized into one of the categories described in Table 2, Crew Performance Categories. During Phase II, the research team collectively developed a method for ranking crew performance using the information recorded by the flight crew observer, the frequency of contacts to ATC to confirm or clarify a clearance, and whether the

flight crew ultimately demonstrated understanding by correctly executing ATC instructions. Table 2 describes this method of categorizing pilot uncertainty for data collection purposes. Category 1 is the most desirable, and categories 4 and 5 are the least desirable.

Table 2. Crew performance categories

FLIGHT CREW	UNCERTAINTY (regarding clearance information, gathered from observed pilot to pilot interaction)	CONTACTS ATC to CONFIRM/CLARIFY CLEARANCE	DEMONSTRATES UNDERSTANDING. AND CORRECTLY EXECUTES ATC INSTRUCTION
CATEGORY 1	NO	NO	YES
CATEGORY 2	YES	NO	YES
CATEGORY 3	YES	YES	YES
CATEGORY 4	NO	NO	NO
CATEGORY 4.5 (added in Phase III)	YES	NO	NO
CATEGORY 5	YES	YES	NO

Overall, the training video significantly improved pilot performance over that which was observed during Phase II simulations. While mentioned upfront in this report, it is stated again here that two of the scenarios were slightly modified from their Phase II versions to align them with the most currently proposed Climb Via procedures and phraseology. These modifications were made based on results from the Phase II results and continuing discussion within the P/CPP AT. Specific training video knowledge areas were targeted for improvement and are discussed later in this section.

The following figures depict Phase III results:

- Figure 1 shows all data points for crew performance as a function of scenario type.
- Figure 2 highlights (circles) those category data points where pilot confusion regarding the FL250 restriction at BIKKR introduced significant uncertainty to the scenario.
- Figure 3 shows overall pilot performance when data points associated with BIKKR confusion are removed.

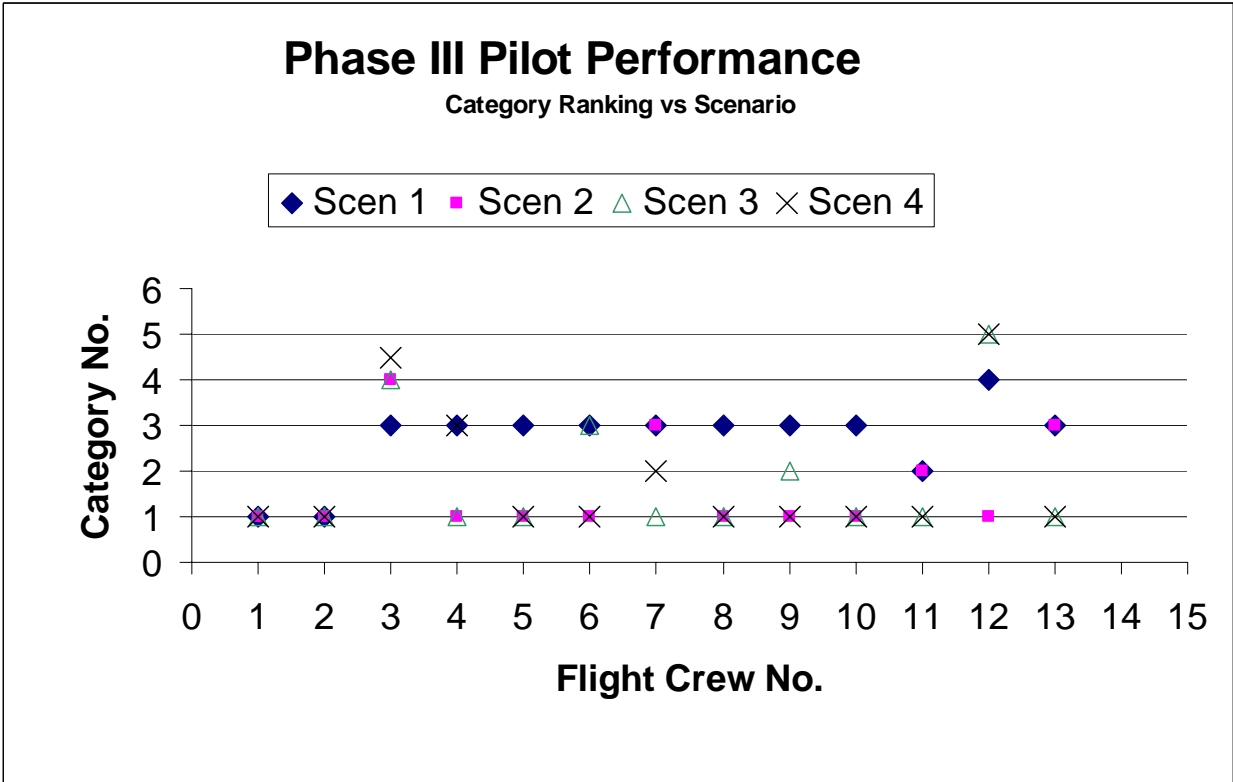
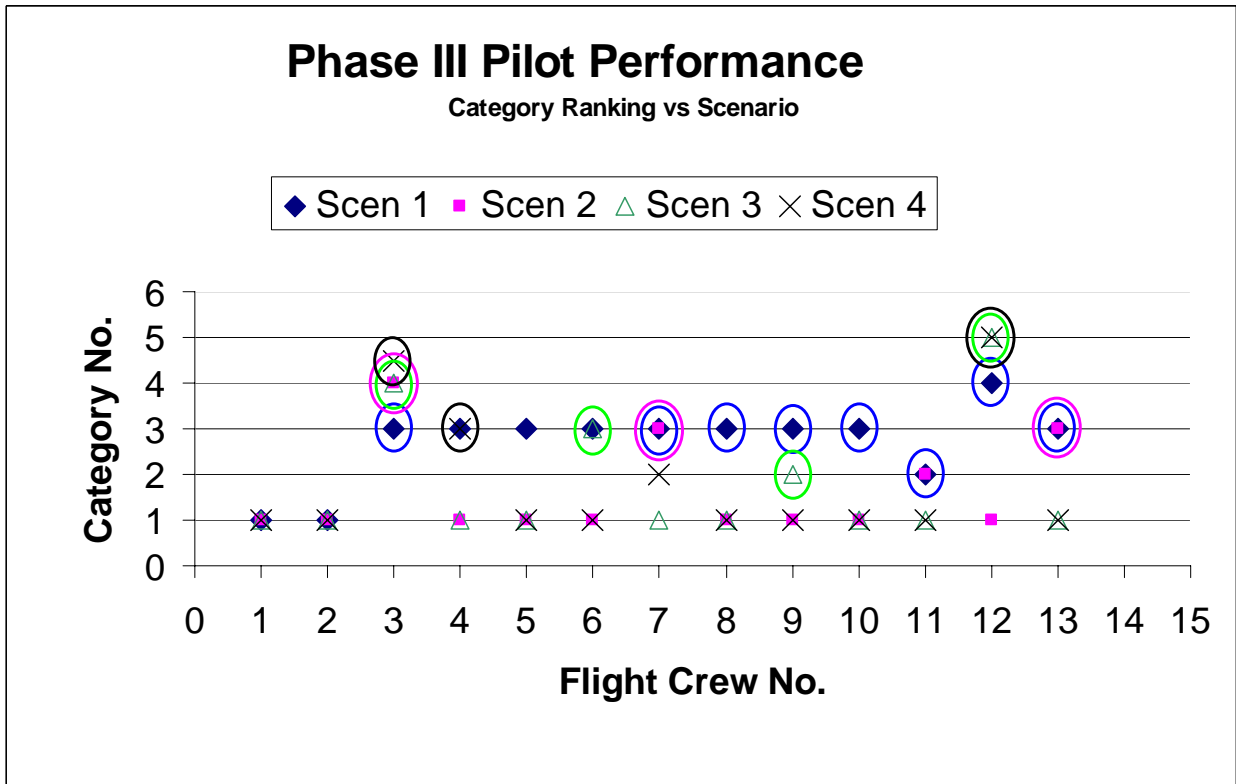


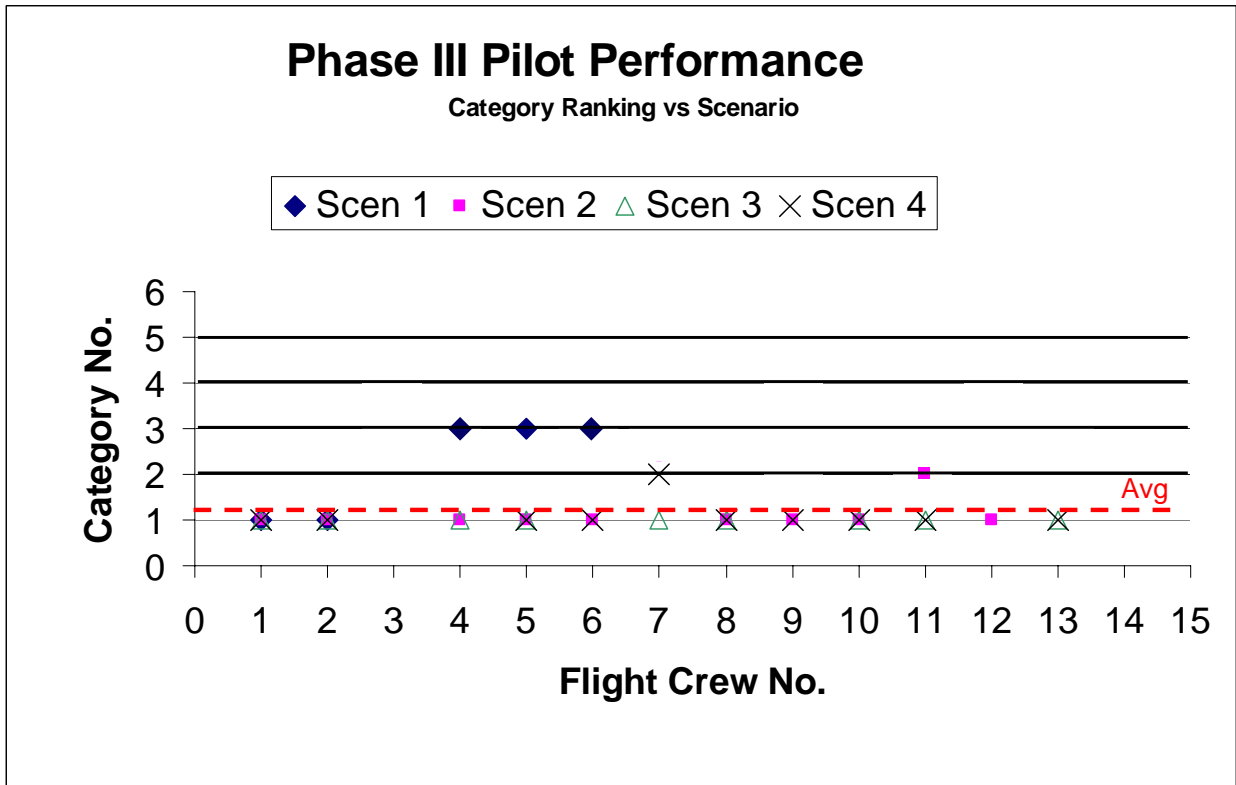
Figure 1. Pilot category data.



Uncertainly due to BIKKR FL250: ○ ○ ○ ○

52 data points
18 BIKKR related confusion

Figure 2. Pilot category data, BIKKR confusion annotated



1.2 Average when uncertainty due to BIKKR removed from data.

Figure 3. Pilot category data, BIKKR confusion purged

4.1 Awareness of SID “Top Altitude”

During Phase II, the majority of participants agreed that lack of altitude information (or awareness of available altitude information) was a significant contributor to ambiguity on the flight deck. The consensus among those Phase II pilots who did notice the top altitude note depicted on the SID plate was that the altitude information needed to be more prominent. The Phase II participants who did not “catch” that information in their initial scans of the plate before each run, commented that the lack of that information coupled with absence of altitude information in the verbal clearance contributed significantly to excess confirmation calls to ATC.

In Phase III, the training video was clearly successful in emphasizing the importance of finding, and briefing the SID Top Altitude before flight. Twelve of thirteen Phase III crews located and specifically verbally briefed the SID Top Altitude during their pre-flight activities. The one crew that did not brief the Top Altitude before takeoff located it and discussed it in-flight, as they approached SHEAD.

4.2 ATC Clearance “Direct-to” in Conjunction with “Climb Via”

In Phase II, participants felt that when cleared “Direct-to” a waypoint on the SID, and cleared to Climb Via the SID, altitude information should always be included in the clearance, regardless of whether altitude information was depicted on the SID for that waypoint. Furthermore, when a clearance involved rejoining a departure procedure, participants recommended that ATC should specify whether the SID and/or other specified altitude is to be reached with or without SID restrictions.

In Phase III, the training video was clearly successful in emphasizing that Climb Via clears the pilot to navigate laterally, and vertically at pilot’s discretion, in order to comply with the altitude restriction either depicted at the waypoint cleared direct-to, or an altitude provided in the stated ATC clearance (e.g., a crossing restriction issued by ATC). During this scenario, there was no pilot uncertainty or hesitation observed. Not one crew asked ATC for clarification regarding when they could start climbing to comply with the relevant altitude restriction (ATC stated or SID depicted). The pilots simply confirmed with each other the start of the climb and altitude climbing to (i.e., standard pilot-to-pilot Crew Resource Management type communications), and immediately started their climb.

4.3 Pre-Flight Flight System Programming and Pilot Briefing(s)

During the time period that Phase II testing was underway, operational issues regarding incorrect runway/SID Flight Management Computer (FMC) programming were emerging at various airports in the NAS. This area of concern was not addressed during Phase II testing.

We were aware of this problem area during Phase III, but because we could not create a realistic simulation environment in which to test this area, we did not address it in simulation. We did,

however, included the topic as a major training objective in the training video. During simulation, we did not inject any runway clearance changes into the scenarios, but we did, nonetheless, observe pilots taking care to check proper programming of their flight data, and often verbally confirming correct runway, SID, and SID transition data in the FMC page(s) prior to takeoff.

In Phase III, therefore, the training video did have a positive effect on pilot awareness of the critical nature of properly programming the entire RNAV route.

4.4 SHEAD FOUR RNAV SID, BIKKR Altitude Restriction

While this study was not a validation of the SHEAD FOUR RNAV departure, it is worth stating the problems we continued to observe with pilot interpretation of the “at or above FL 250” restriction at the BIKKR waypoint. The data in the Figure 2 graphically shows that pilot uncertainty regarding BIKKR’s altitude significantly contributed to poor performance.

Many pilots considered the BIKKR restriction, but correctly maintained their decision to maintain FL190. Other pilots offered that if they did not receive higher from ATC far enough in advance of BIKKR that making the FL250 restriction would be in question, they would certainly contact ATC for further instructions.

One pilot convinced himself that the BIKKR altitude restriction was a “Transition Top Altitude” for the SHEAD FOUR SID, and therefore believed he was cleared to FL250 after SHEAD. After the simulation, he offered that operationally, he would have contacted ATC for clarification. This particular pilot kept referring back to his recollection of how the training video emphasized that certain SID’s may specify different Top Altitudes per transition.

While issues surround BIKKR introducing confusion, and its potential for generating unnecessary voice communications with ATC are real, it should also be noted that if operationally, aircraft are handed-off from Las Vegas Departure to adjacent ARTCCs prior to aircraft reaching altitudes at which the BIKKR altitude becomes a factor, then this problem may not be nearly as severe as it seems in simulation. In these simulations, we commonly let the pilots continue (under Departure Control) longer than operationally realistic, in order to fully observe their understanding of the SID Top Altitude.

4.5 Pilot Difficulty with Long Clearances

An interesting observation, not necessarily associated with the implementation of Climb Via phraseology itself, but nonetheless evidenced during this study, was that of pilot difficulty with long clearances. Particularly in Scenario 4, the length of the clearance caused some difficulty for the pilots. Eight crews had some difficulty with the following clearance:

“American 1721, Fly heading Two Three Zero to join, Cross SHEAD at or above One Four Thousand, CLIMB VIA the SHEAD FOUR RNAV departure.”

This lengthy clearance generated a number of conditions:

- Read back incorrect; generated unnecessary ATC communication
 - o In this case, ATC caught the error, and restated the clearance
- Read back correct, but later recalled incorrectly; could have resulted in non-compliance.
 - o In this case the pilot crossed at 14,000 FT when cleared “at or above.” This technically complies with the clearance, but the issue here is that the pilot recalled, in error, that he was to “cross at” rather than “at or above.”
- Pilot-to-ATC request for repeat of the clearance; unnecessary ATC communication
 - o In this case, ATC simply re-stated the clearance

4.6 “Top Altitude” as a New ATC Term

Three pilots expressed concern regarding the introduction of a new term, “SID Top Altitude,” but went on to say that they did understand the term after watching the video. One pilot suggested the term “SID Climb Limit.”

The P/CPP AT will propose a “SID Top Altitude” definition to be added to industry controller and pilot ATC glossaries.

4.7 No Altitude in Departure Clearance

One of 26 pilot participants was adamant that if the crew is expected to fly the SID, with restrictions, then the words “Climb Via” should be stated in the departure clearance (spoken or PDC) itself.

This specific request will not be implemented, but this pilot’s concern might be mitigated by the following:

- The Climb Via pilot training video specifies that clearance for the departure procedure is in effect, instruction to Climb Via the procedure, which includes restrictions.
- Additionally, the Climb Via pilot training video includes the pilot’s responsibility to provide in his/her initial contact with Departure Control, that he/she is leaving their current altitude for the SID Top Altitude, Climbing Via the SID. For example, on the SHEAD FOUR RNAV departure, Transamerican 209 flight would check in with Departure Control by stating:

“Las Vegas Departure, Transamerican 209, leaving 3,500 FT for FL190, **Climbing Via** the Shead Four Departure.”

4.8 Pilot Training Video Written Test Discussion

All of the pilots answered all seven questions correctly, although four pilots declined to rely solely on ATC for terrain and obstacle clearance when ATC directed them off of the published SID. Very few pilots explicitly wrote that a Climb Via clearance included clearance to navigate vertically *at pilot's discretion*, although all offered this when pressed for clarification during debrief with the test team. More importantly, all pilots demonstrated this understanding through their actions during the simulations.

5. Discussion/Recommendations

Overall, the data clearly shows that the Climb Via pilot training video is an effective way to train pilots regarding the Climb Via and RNAV training objectives listed in Section 3.4.

The P/PPP, chaired by a representative from the FAA RNAV/RNP Group, and the NAS Modernization Team, Air Line Pilots Association, International, recommended that the video be prepared for wide dissemination amongst the pilot community.

Three minor changes are being made to the video:

- Minor changes to the introductory text, advising pilot viewers that this video is provided to promote familiarity, and is not a formal training product. Viewers will be reminded to review sources commonly referred to for regulatory guidance (e.g. FAA Order 7110.65, relevant Advisory Circulars, Aeronautical Information Manual, and the Aeronautical Information Publication).
- The importance of proper phraseology by the pilot, upon initial contact with Departure Control will be further emphasized.
- The ATC clearance in video scenario number three will be slightly edited as follows:

Original text:

“Transamerican 209, Climb Via the PRYME TWO departure, except after RAISN, maintain 12,000 FT, I say again, after RAISN, maintain one two thousand.”

Modified text:

“Transamerican 209, Climb Via the PRYME TWO departure, except after RAISN, maintain 12,000 FT.”

The video will be packaged as a Windows Media Video Format (wmv file), for hosting on a number of aviation web sites, to be determined. Proposed operational implementation of Climb Via phraseology is scheduled for early 2007 at Las Vegas TRACON, with implementation in other locations throughout the NAS to follow an initial operational trial period in LAS TRACON.

Appendix A.

References

Federal Aviation Administration (2004). *Air traffic control* (DOT/FAA/Order 7110.65P)
Washington, DC: Federal Aviation Administration.

Appendix B.

Acronyms

AIM	Aeronautical Information Manual
AIP	Aeronautical Information Publication
ATC	Air Traffic Control
CRM	Crew Resource Management
CVSRF	Crew Vehicle Systems Research Facility
DME	Distance Measuring Equipment
DCP	Document Change Proposal
FAA	Federal Aviation Administration
FMS	Flight Management System
GPS	Global Positioning System
HUD	Heads-up Display
LAS	Las Vegas/McCarran International Airport
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
P/PPAT	Pilot Controller Phraseology and Procedures Action Team
PRM	Precision Runway Monitor
RNAV	Area Navigation
RNP	Required Navigation Performance
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival Route
WJHTC	William J. Hughes Technical Center

Appendix C.

Draft Document Change Proposal (DCP)

Note: This was the current draft DCP at the time of the study.



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

NOTICE
N 7110. XX

Effective Date:
March 15, 2007

SUBJ: ALTITUDE INFORMATION

Purpose. This notice prescribes Air Traffic Control (ATC) procedures and phraseology to use when issuing Climb Via instructions to aircraft navigating along Standard Instrument Departure (SID) routes.

Who This Notice Affects. This notice is distributed to select offices in Washington Headquarters, Mike Monroney Aeronautical Center, all ARTCC and TRACON facilities in the National Airspace System (NAS).

Effective. March 15, 2007

Background. The Pilot/Controller Procedures and Phraseology Working Group (P/CPP) was established to address RNAV and RNP implementation issues. The P/CPP is made up of air traffic, aviation, and union subject matter experts. The P/CPP reviews, assesses and proposes changes to ATC procedures and phraseology and is tasked with incorporating those changes into FAA Order 7110.65, the AIM and AIP.

The P/CPP has validated an operational need to develop and implement a new procedure called Climb Via has been designed using procedures and phraseology consistent with "Descend via".

Related Publications. FAAO 7110.65, Air Traffic Control

Definitions / Abbreviations.

- a. Standard Instrument Departure (SID). A preplanned instrument flight rule (IFR) ATC departure procedure printed for pilot/controller use to provide obstacle clearance and a transition from the terminal to the enroute structure.
- b. SID Top Altitude. – SID Top Altitude, or top altitude, is the maximum altitude you are cleared to climb to in the initial SID clearance, or when receiving a Climb Via clearance. The SID top altitude will always be found in either the narrative text of the procedure, or assigned by ATC. The SID Top Altitude may or may not be depicted on the procedure graphic, or associated with a waypoint on the procedure. All preceding altitude and speed restrictions must be complied with prior to reaching the SID top altitude.

Procedures.

4-5-7 ALTITUDE INFORMATION

j. Instructions to vertically navigate on a SID with published restrictions must be issued after an aircraft is taken off a SID and then instructed to rejoin the SID, after the aircraft is given an altitude restriction that stops the normal climb on a SID or after transfer of control when the controller is stating a new altitude for the aircraft to climb to in their sector.

PHRASEOLOGY-

CLIMB VIA (SID name and number), EXCEPT AFTER (waypoint name) MAINTAIN (assigned alt.).

NOTE-

Issuing “Climb Via” and an altitude to maintain while an aircraft is on a SID without stating a waypoint where the maintain altitude becomes a mandatory climb authorizes the pilot to climb unrestricted on the SID.

EXAMPLE-

“Climb Via the Johnn Two Departure, except after Baret maintain flight level one-niner-zero.”

NOTE-

Clearance to “Climb Via” authorizes pilots:

- 1. To navigate laterally, and vertically at pilot’s discretion on a SID.*
- 2. To climb at their discretion to comply with all restrictions when cleared direct-to a waypoint with a published altitude restriction.*

EXAMPLE-

“Proceed direct Samul, Climb Via Evann Two Departure.”

NOTE-

While an aircraft is off the SID, ATC is responsible for obstacle clearance when issuing a “Climb Via”

clearance from a previously assigned altitude.

REFERENCE-

FAAO 7110.65, Minimum En Route Altitudes, Para 4-5-6.

FAAO 7110.65, Separation From Obstructions, Para 5-5-9.

PHRASEOLOGY-

(ACID) leaving(present altitude) for (top altitude or as assigned by ATC), climbing via (SID name and number)

NOTE-

Frequency change -Pilots cleared for SIDs with vertical constraints shall inform ATC upon initial contact.

EXAMPLE –

“Cactus Seven Eleven leaving two thousand for flight level one-niner-zero, climbing via the Laura Two departure.”

1. When an aircraft is off the SID then cleared direct to a waypoint without a published altitude restriction, ATC shall assign an altitude to cross the waypoint/fix.

EXAMPLE-

“Proceed direct Rockr, cross Rockr at or above one-zero thousand, Climb Via the Bizee Two Departure.”

2. When an aircraft is off the SID, ATC may assign a heading to intercept and instruct the aircraft to “Climb Via” the SID only if altitude information is contained in the clearance.

EXAMPLE-

“Cactus seventy seven, turn left heading two-five-zero and join the Bizee Two departure cross Rodny at or above one-four thousand, Climb Via the Bizee Two departure.”

3. If it is necessary to assign a crossing altitude at a waypoint which differs from a published altitude, the term “except” shall be used to emphasize the change to the pilot.

PHRASEOLOGY-

CLIMB VIA THE (SID) EXCEPT CROSS (Fix, Point, Waypoint), (revised altitude information).

EXAMPLE-

“American Two Ten “Climb Via” the Suzan Two departure, except cross “Mkala” at or above seven thousand

NOTE-

The aircraft should track laterally and vertically on the Suzan Two departure and should climb so as to cross Mkala at or above 7,000; remainder of the departure shall be flown as published.

4. If it is necessary to assign an interim altitude that is not published on the SID, advise the pilot where the altitude assignment begins.

PHRASEOLOGY-

CLIMB VIA THE (SID) EXCEPT AFTER (fix) MAINTAIN (revised altitude information).

EXAMPLE-

“Cactus Seven Eleven “Climb Via” the Edwin One Departure, except after Meemy, maintain one five thousand”

5. ATC may also assign or change an altitude and/or speed restriction prior to issuing the “Climb Via” instruction.

PHRASEOLOGY-

CROSS (fix) AT (altitude/speed information) THEN CLIMB VIA (SID)

EXAMPLE -

“American Two Ten cross Alisa at one zero thousand and two two zero knots, then “Climb Via’ Timmy One Departure.”

NOTE-

The aircraft should track laterally on the Timmy One Departure in order to cross “Alisa” at 10,000 and 220 knots. Upon crossing “Alisa” at 10,000, the aircraft should then track laterally and vertically as published, resuming normal speed for the segment if applicable, until reaching the top altitude for the SID.

Appendix D.

Participant Consent Form

Consent Form

I, _____, understand that the FAA Air Traffic Procedures Office (ATP-500) and FAA Flight Standards sponsor and direct this effort entitled *Evaluation of Modified Air Traffic Control Phraseology for Area Navigation (RNAV) Standard Instrument Departure Clearances*.

I. Nature and Purpose:

I agree to volunteer as a participant in the study cited above. I understand the purpose of this evaluation is to provide the feedback on the utility, effectiveness, and safety of the proposed new controller phraseology for communicating RNAV SIDS to pilots. I will make recommendations and suggestions with respect to procedural, communication, and/or other relevant issues that would enhance the understanding of new RNAV SIDS departure phraseology.

II. Participant Responsibilities:

My information will be gathered through narrative descriptions of the actions I would take within the cockpit in the context of selected RNAV departure scenarios in order to characterize the nature of any potential problem(s) that may exist in interpreting and executing RNAV SID clearances using the proposed Climb Via phraseology.

III. Discomforts and Risks:

There are no expected discomforts or risks associated with this experiment.

IV. Participant Assurances:

I understand that my participation in this study is completely voluntary. I understand that if new findings develop during the course of this research that may relate to my decision to continue to participation, I will be informed. I understand that I can withdraw from the study at any time without penalty or loss of benefits to which I may be entitled. I also understand that the researcher of this study may terminate my participation if he/she feels this to be in my best interest.

I understand that records of this study are strictly confidential, and that I will not be identifiable by name or description in any reports or publications about this study

I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I have received a copy of this consent form.

Research Participant : _____ Date: _____

Appendix E.
Climb Via Pilot Training Video Written Test

Climb Via Pilot Training Video Questionnaire

(1) Explain what a “Climb Via” clearance means?

Answer:

(2) In what location(s) would you find the SID “Top Altitude?” Explain the significance of the SID “Top Altitude.”

Answer:

(3) When are you allowed to climb to your filed/requested altitude?

Answer:

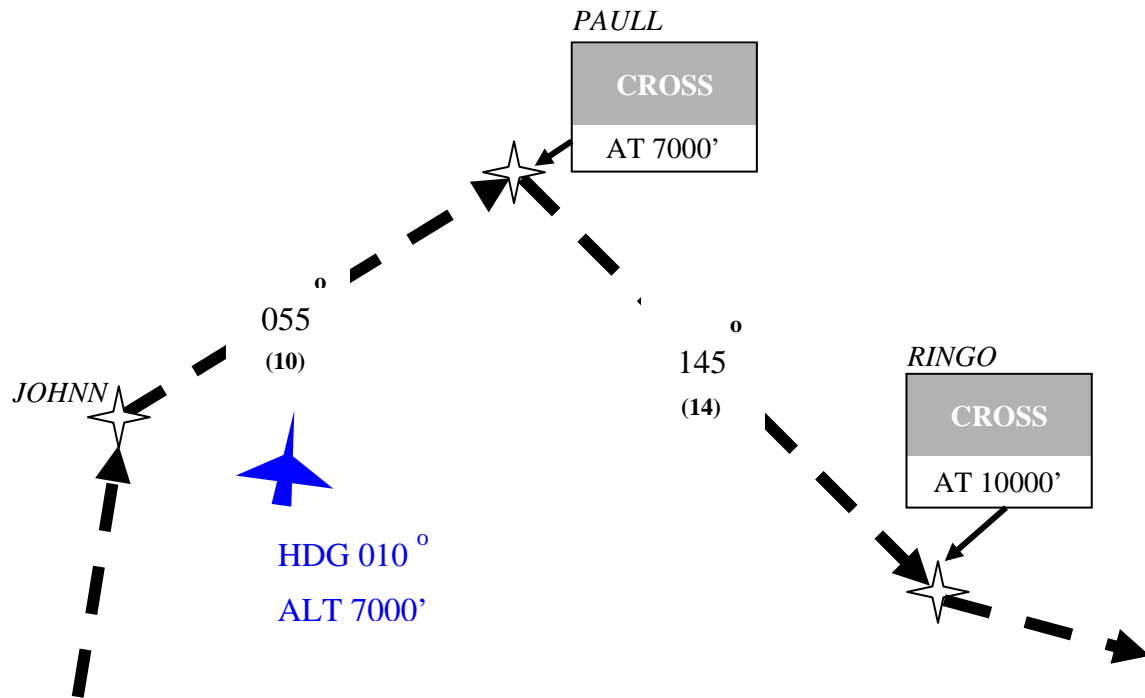
(4) ATC has vectored you off a published routing and assigned an altitude to maintain. Then ATC issues you a discretionary climb or descent. Who is responsible for terrain and obstacle clearance while you are off the published routing?

Answer:

(5) You are currently off the published SID at the position shown, instructed to maintain 7,000 FT, on an ATC issued 010° vector. ATC then issues the following clearance:

“Transamerican209, Fly Heading Zero Niner Zero to Join, Cross RINGO at 10,000 FT, CLIMB VIA the BUBBA FIVE departure”

What actions do you take and when, in order to comply with this clearance?

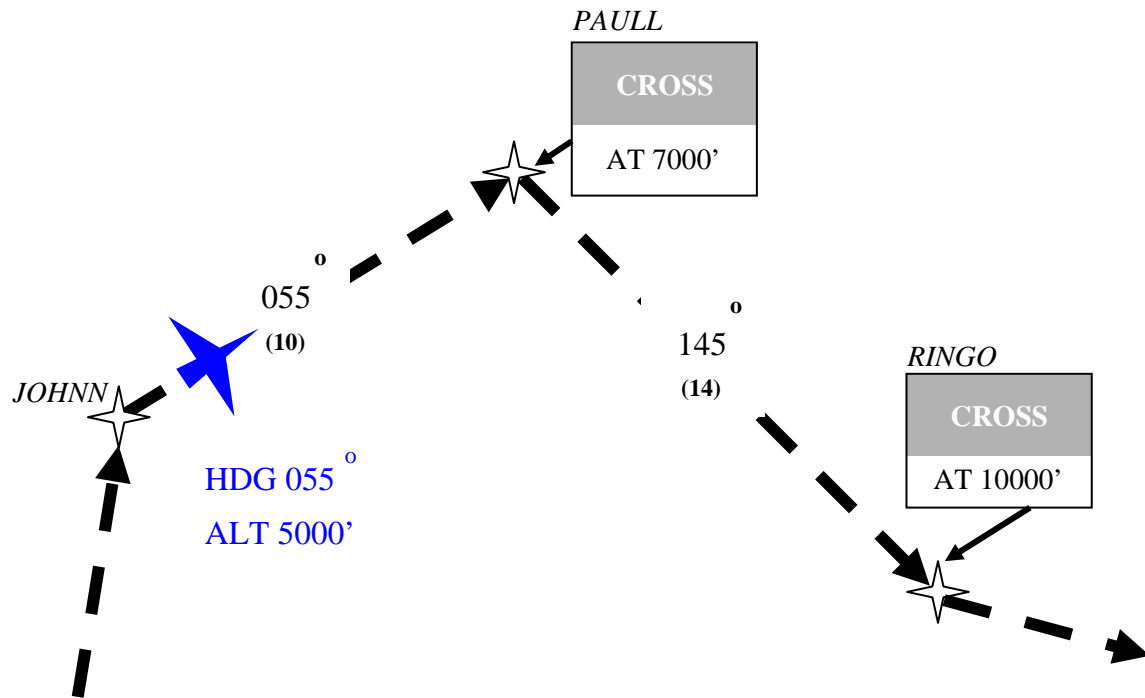


Answer:

(6) You are currently at the position shown, climbing through 5,000 FT, on course to PAULL. ATC then issues the following clearance:

“Transamerican209, Cleared Direct RINGO, CLIMB VIA the BUBBA FIVE departure”

What actions do you take and when, in order to comply with this clearance?

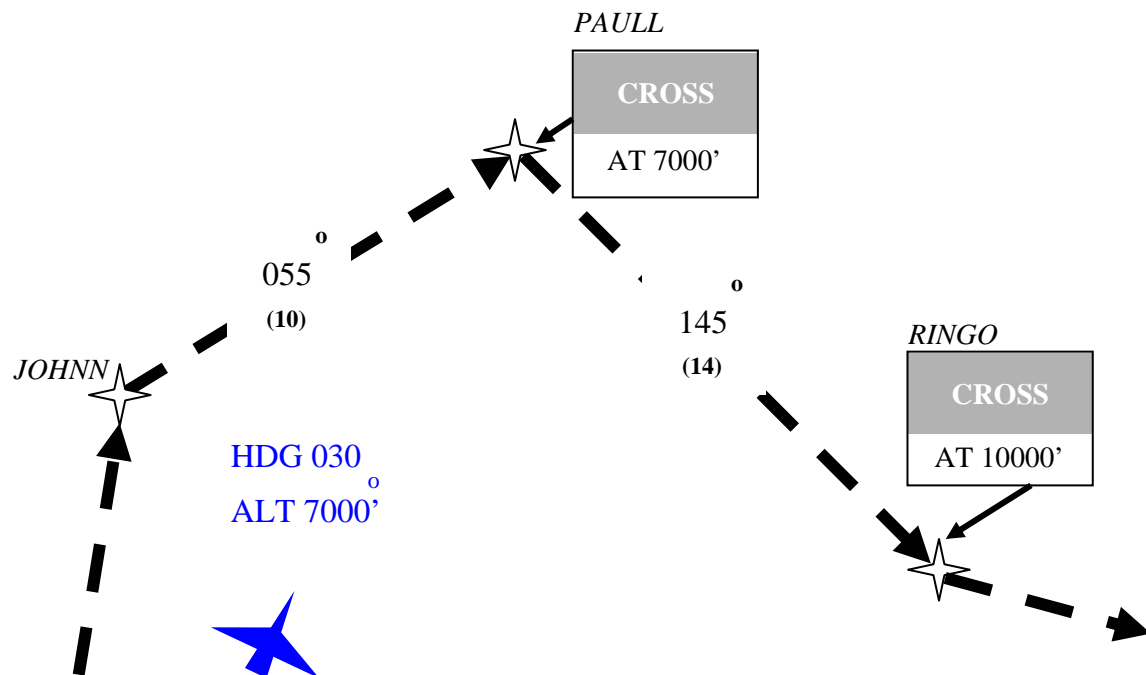


Answer:

(7) You are currently off the published SID at the position shown, instructed to maintain 7,000 FT, on an ATC issued vector direct PAULL. ATC then issues the following clearance:

“Transamerican209, Cleared Direct RINGO, CLIMB VIA the BUBBA FIVE departure”

What actions do you take and when, in order to comply with this clearance?

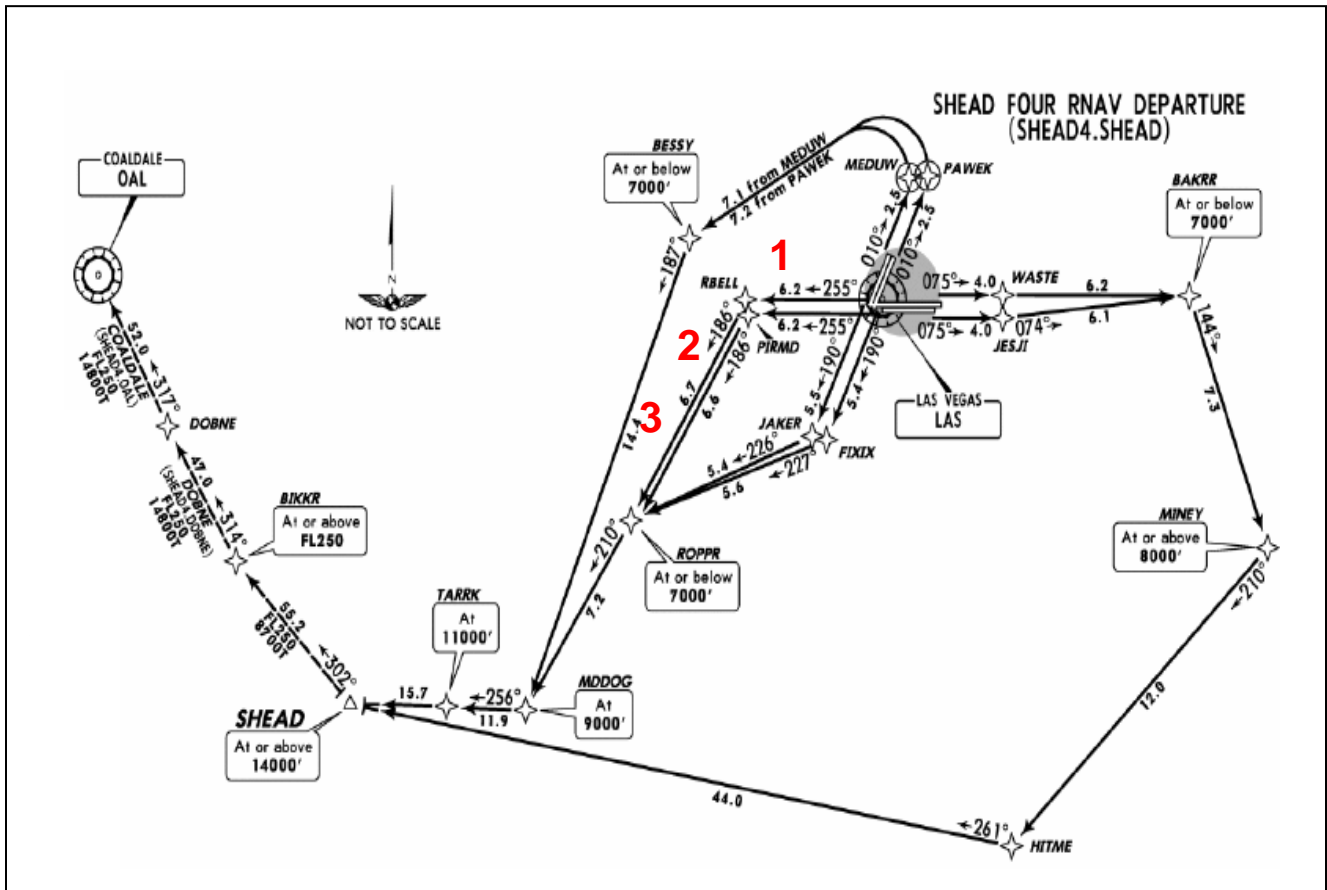


Answer:

Appendix F.

Scenario Descriptions and Associated ATC Phraseology

Scenario Descriptions

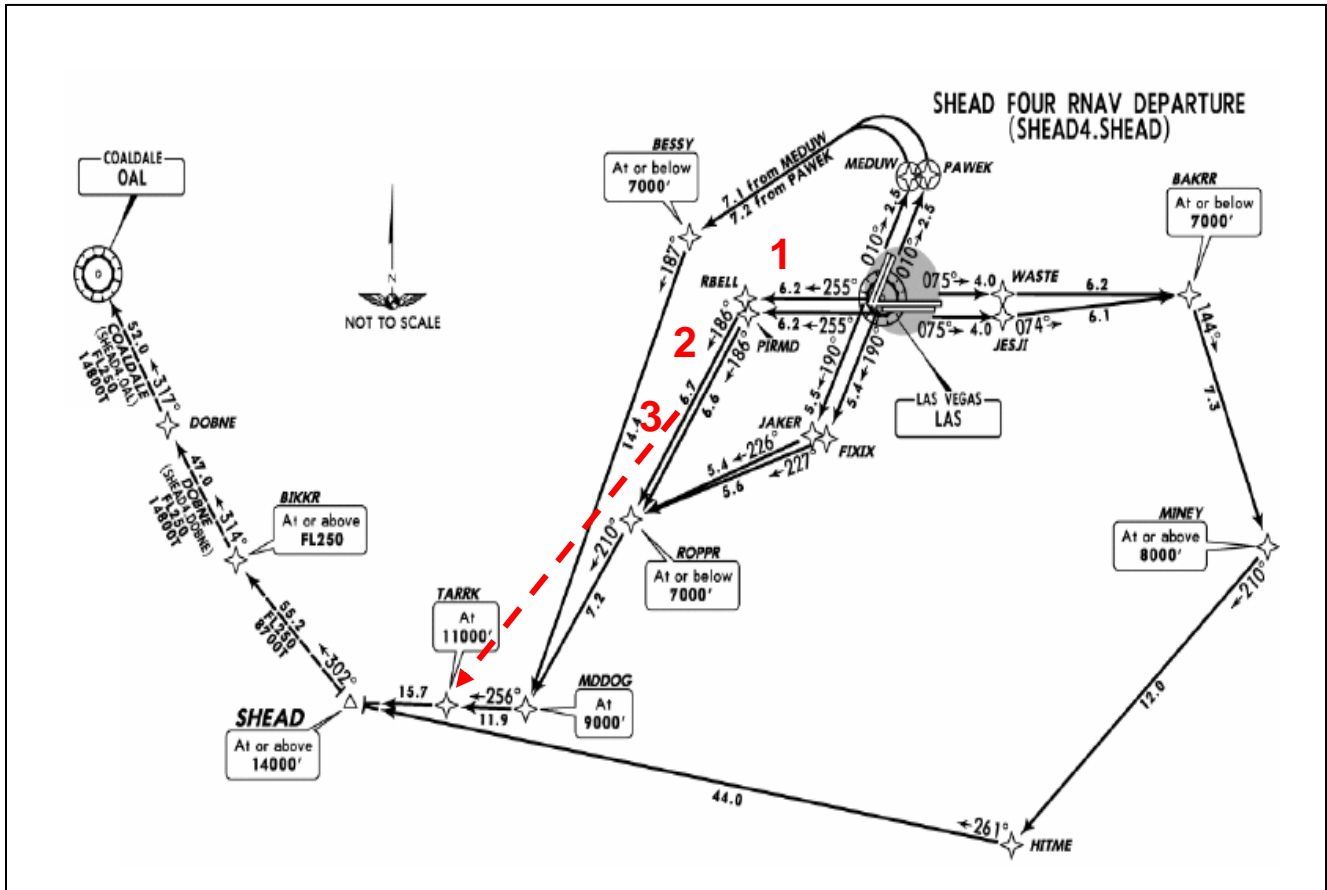


Scenario 1: Speed change and downstream SID restriction change.

ATC Phraseology

- American 1721, cleared to SEA, via the SHEAD FOUR RNAV departure COALDALE transition as filed, squawk 2432
- American 1721, taxi to 25R
- American 1721, taxi into position and hold: cleared for takeoff
- American 1721, Contact Departure 125.9
- American 1721, Radar Contact
- **1. American 1721, reduce speed to two-three zero (should be issued at about 5700').**
- **2. American 1721, resume normal speed**
- **3. American 1721, Climb Via the SHEAD FOUR RNAV departure, except cross SHEAD at one four thousand, I say again cross SHEAD at one four thousand.**
- American 1721, contact LA Center 124.25

Scenario Descriptions

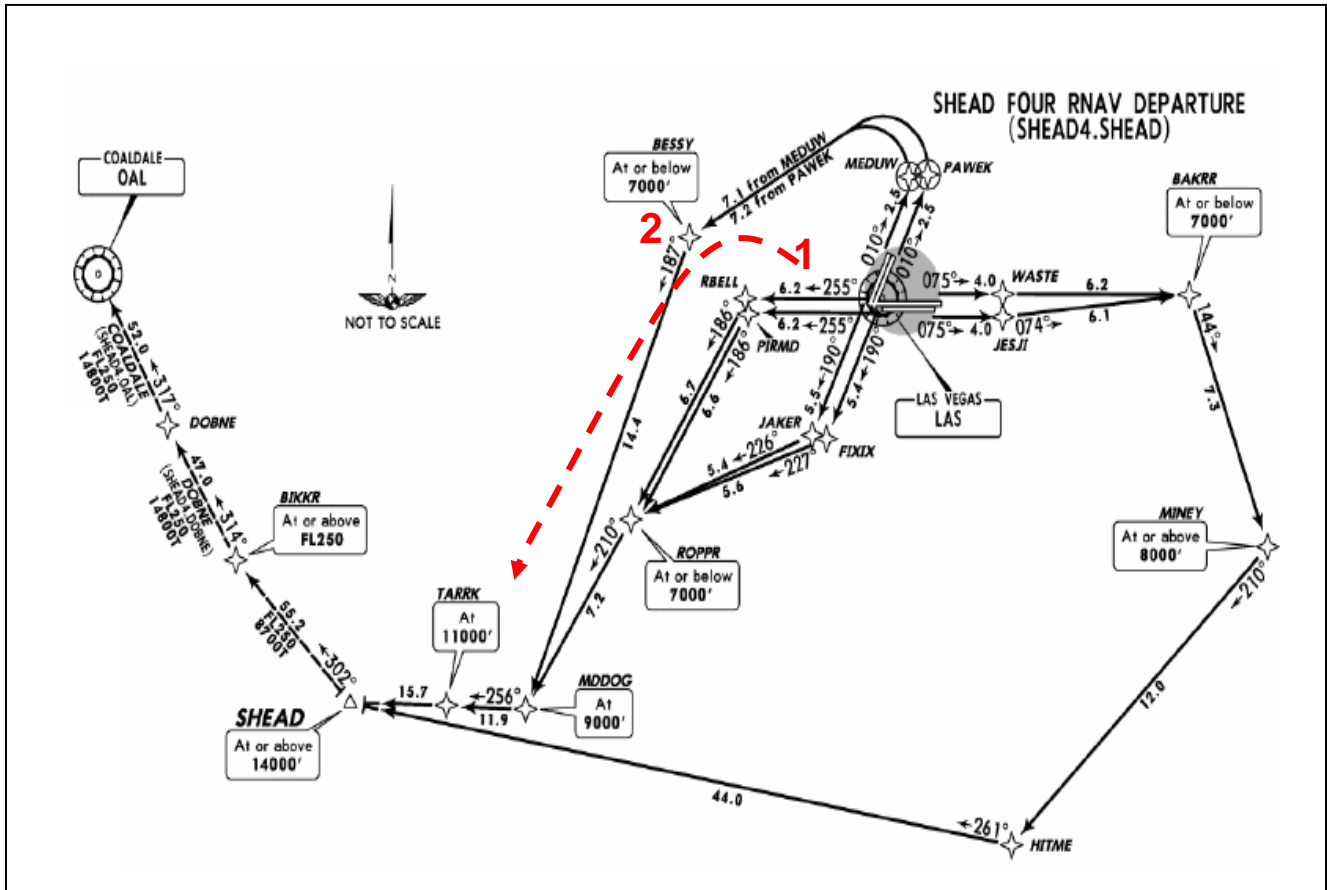


Scenario 2: Altitude restriction change, followed by a short-cut.

ATC Phraseology

- American 1721, cleared to SEA, via the SHEAD FOUR RNAV departure COALDALE transition as filed, squawk 2432
- American 1721, taxi to 25R
- American 1721, taxi into position and hold: cleared for takeoff
- American 1721, Contact Departure 125.9
- American 1721, Radar Contact
- **1. American 1721, maintain seven thousand for traffic expect higher in ten miles.**
- **2. American 1721, traffic no longer a factor CLIMB VIA the SHEAD FOUR RNAV departure.**
- **3. American 1721, proceed direct TARRK, Climb Via the SHEAD FOUR RNAV departure.**
- American 1721, contact LA Center 124.25

Scenario Descriptions

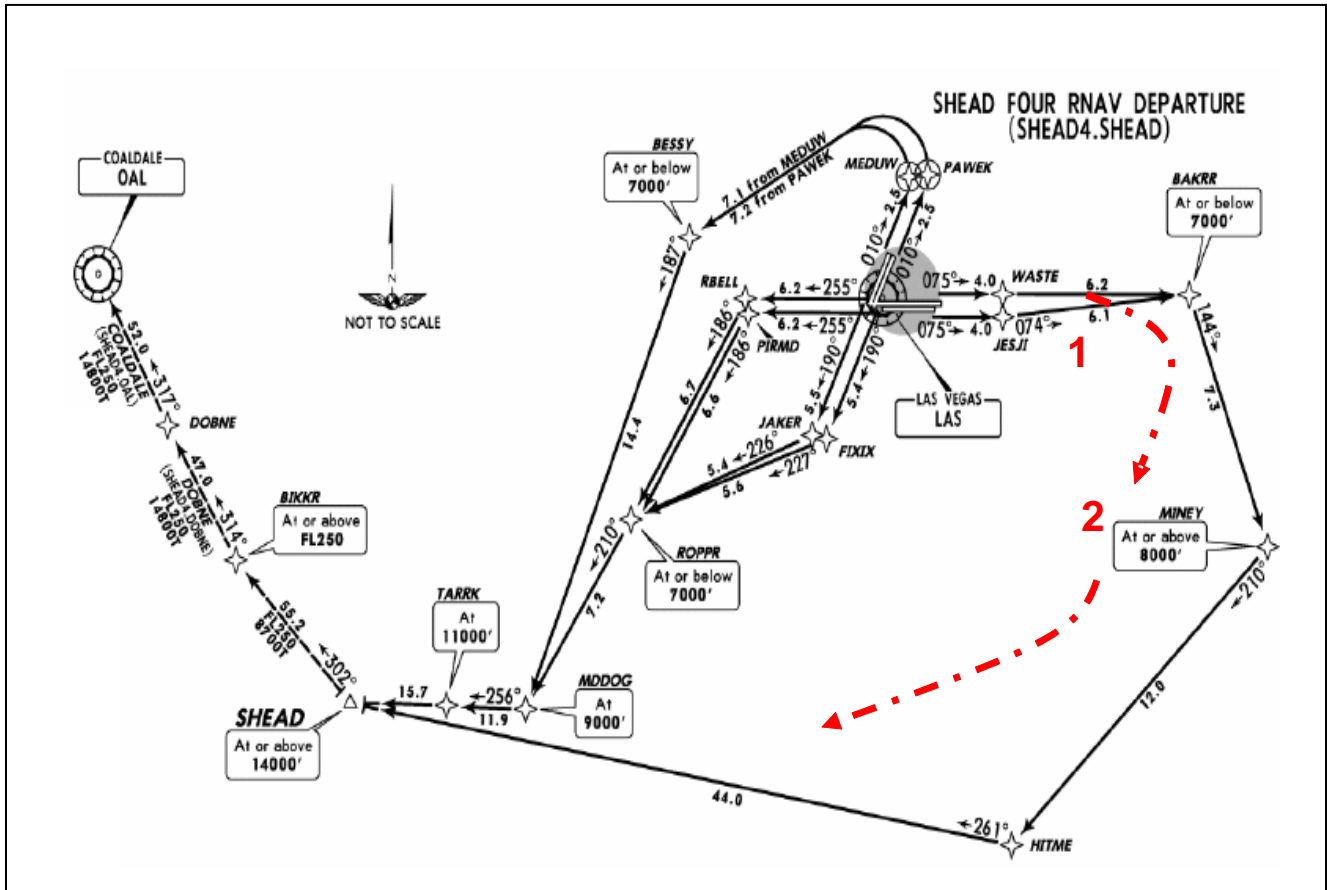


Scenario 3: Vector off departure (w/heating and altitude restriction), followed by a short-cut back on SID.

ATC Phraseology

- American 1721, cleared to SEA, via the SHEAD FOUR RNAV departure COALDALE transition as filed, squawk 2432
- American 1721, taxi to 25R
- American 1721, taxi into position and hold: cleared for takeoff
- American 1721, Contact Departure 125.9
- American 1721, Radar Contact
- 1. American 1721, Fly heading two seven zero, vector for spacing maintain seven thousand, expect direct TARRK.**
- 2. American 1721, Proceed direct TARRK, CLIMB VIA the SHEAD FOUR RNAV departure**
- American 1721, contact LA Center 124.25

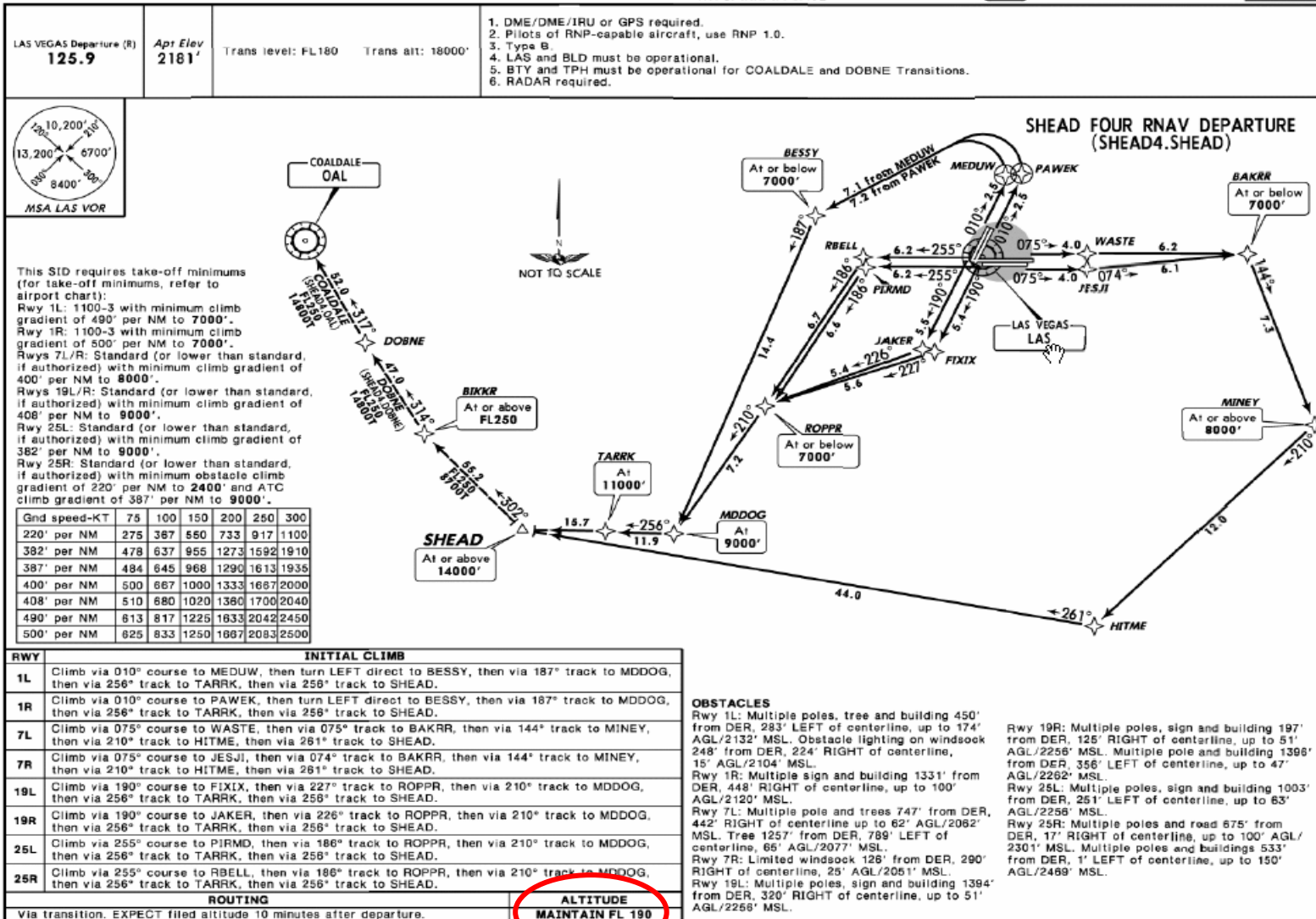
Scenario Descriptions



Scenario 4: Short-cut, followed by a vector and clearance to CLIMB VIA

ATC Phraseology

- American 1721, cleared to SEA, via the SHEAD FOUR RNAV departure COALDALE transition as filed, squawk 2432
- American 1721, taxi to 7L
- American 1721, taxi into position and hold: cleared for takeoff
- American 1721, Contact Departure 125.9
- American 1721, Radar Contact
- **1. American 1721, Proceed direct HITME maintain niner thousand, expect vectors to resume the SHEAD FOUR RNAV departure.**
- **2. American 1721, Fly heading two three zero to join, Cross SHEAD at or above one four thousand, CLIMB VIA the SHEAD FOUR RNAV departure**
- American 1721, contact LA Center 124.25



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Figure 4. SHEAD FOUR SID Plate with SID “Top Altitude” Note